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2014 Global geographic analysis of mortality from ischaemic heart disease by country, age and income: Statistics from World Health Organisation and United Nations

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ABSTRACT

Background: Ischaemic heart disease (IHD) is the leading cause of death worldwide and its prevention is a public health priority.
Method: We analysed worldwide IHD mortality data from the World Health Organisation as of February 2014 by country, age and income. Age-standardised mortality rates by country were calculated. We constructed a cartogram which is an algorithmically transformed world map that conveys numbers of deaths in the form of spatial area.
Results: Of the countries that provided mortality data, Russia, the United States of America and Ukraine contributed the largest numbers of deaths. India and China were estimated to have even larger numbers of deaths. Death rates from IHD increase rapidly with age. Crude mortality rates appear to be stable whilst age-standardised mortality rates are falling. Over half of the world's countries (113/216) have provided IHD mortality data for 2008 or later. Of these, 13 countries provided data in 2012. No countries have yet provided 2013 data. Of the 103 remaining countries, 24 provided data in 2007 or earlier, and 79 have never provided data in the ICD9 or ICD10 format.
Conclusions: In the countries for which there are good longitudinal data, predominantly European countries, recent years have shown a continuing decline in age-standardised IHD mortality. However, the progressive aging of populations has kept crude IHD mortality high. It is not known whether the pattern is consistent globally because many countries have not provided regular annual data including wealthy countries such as the United Arab Emirates and large countries such as India and China.

1. Introduction

Ischaemic heart disease (IHD) is the single leading cause of death worldwide, accounting for 11.2% of all deaths globally in 2011 [1], the last year for which a reliable estimate is available. Our group has previously studied the global epidemiology of IHD from 1995 to 2009 [2]. In this paper we provide an update, reporting on the burden of IHD worldwide from 2001 to 2012 using mortality data collected by the World Health Organisation (WHO). We present IHD mortality by country, age and income category.

Our update also provides a geographical analysis of IHD mortality [3] using a cartogram, a world map in which the area of each country is algorithmically transformed so that it is proportional to a measured variable for that country, in this case, number of deaths. The value of cartograms over and above typical map display is that it illustrates the spatial representation of a variable of interest whilst retaining the semblance of a world map.

Analysing the emerging global pattern of IHD mortality at regular time intervals is necessary to inform and update public health strategy. Collection of raw mortality data categorised by cause of death is integral to this, but limited raw data seem to be available even from countries whose resource position might be expected to permit an exemplary role in the promptness and completeness of data collection and disclosure. Public health bodies such as the WHO and the Institute for Health Metrics and Evaluation (IHME) therefore use sophisticated methods to provide estimates [4,5]. The disadvantage of estimation is the inevitable introduction of some degree of error [6]. In this paper, we highlight countries with limited available data.

2. Methods

2.1. Data sources

IHD mortality and population data were extracted from the online WHO mortality database. This comprises all deaths registered by national civil registration systems

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submitted to the WHO, with underlying cause of death coded by the relevant national authority using the International Statistical Classification of Diseases and Related Health Problems (ICD) 9th and 10th revisions [7]. Gross national income per capita was extracted from the National Accounts Main Aggregates Database from the United Nations Statistics Division [8]. Countries were categorised into high (greater than US $12,275), upper middle ($3976 to $12,275 inclusive), lower middle ($1006 to $3975 inclusive) and low (less than $1006) income countries based on World Bank Income Grouping [9].

2.2. Directly standardised mortality rates

IHD deaths for countries with available age-specific data were standardised to the WHO world standard population [10] to allow direct comparison of IHD mortality rates between countries. Standardised mortality rates were calculated using deaths reported within 5-year age groups. The small numbers of deaths in the "unspecified" age group were discounted in this analysis.

2.3. Cartogram

A cartogram was designed to illustrate the worldwide distribution of IHD deaths using 2010 estimates of IHD deaths from the IHME [11]. The area for each country is algorithmically transformed so that it is proportional to the number of deaths from IHD in each country. After transforming the area to represent number of deaths (the first variable of interest), we use gradations of colour to represent standardised mortality ratio (the second variable of interest) with darker shades of red representing countries with higher standardised mortality ratios.

The cartogram was generated using ScapeToad-v11 and R (Version 3.0, R Foundation) with the following packages: shapefiles, rgdal, RColorBrewer and classInt.

Data analysis was carried out using a custom Python script (Python 2.7.6 with Pandas 0.12.0).

3. Results

3.1. Burden of IHD worldwide in 2010

Table 1 shows the burden of IHD deaths in 2010 in countries for which data were available. Of these 71 countries, Russia, the United States of America and Ukraine account for the largest numbers of deaths. Startlingly, Ukraine had almost as many deaths as the United States of America yet the United States of America's population is over 6 times larger than that of Ukraine.

The global distribution of deaths from IHD has been estimated for the majority of countries in 2010. This is illustrated in Fig. 1 in the form of a map where country area has been transformed to provide a visual representation of the numbers of deaths: larger country areas indicate larger numbers of deaths. The five countries with the greatest numbers of estimated deaths are India, China, Russia, the United States of America and Ukraine in descending order. The darker shaded areas indicate higher standardised mortality ratios. The five with the highest rates are Turkmenistan, Ukraine, Belarus, Uzbekistan and Kazakhstan in descending order.

3.2. Impact of age on IHD mortality

Fig. 2a–d shows the large increase in mortality in each sex in the 4 countries selected (Ukraine, Russia, the United Kingdom and Japan)

Table 1
Global burden of IHD deaths. Ranked by country burden.
Data from the World Health Organisation 2010.

High income			Upper middle income			Lower middle income			Low income		
Rank	Country	Number	Rank	Country	Number	Rank	Country	Number	Rank	Country	Number
1	United States of America	379,709	1	Russia	597,921	1	Ukraine	314,672	1	Kyrgyzstan	10,874
2	Germany	133,126	2	Brazil	99,955	2	Moldova	16,566			
3	United Kingdom	80,568	3	Mexico	69,082	3	Egypt	14,213			
4	Japan	77,217	4	Romania	53,297	4	Armenia	8212			
5	Italy	72,498	5	Poland	45,832	5	Georgia	3202			
6	France	35,531	6	Hungary	33,842	6	Paraguay	2404			
7	Spain	35,268	7	Kazakhstan	19,431	7	Nicaragua	2264			
8	Czech Republic	25,178	8	Argentina	19,428						
9	Australia	21,718	9	Cuba	16,630						
10	Slovakia	16,944	10	Lithuania	15,112						
11	Sweden	15,012	11	Bulgaria	13,330						
12	Austria	14,941	12	Serbia	12,082						
13	Republic of Korea	13,336	13	Latvia	8591						
14	Finland	11,767	14	Dominican Republic	4681						
15	Greece	11,332	15	Peru	4580						
16	Croatia	11,264	16	Costa Rica	2578						
17	Netherlands	10,382	17	Ecuador	1994						
18	Belgium	9310	18	TFYR Macedonia	1752						
19	Switzerland	8314	19	Mauritius	1067						
20	Portugal	7504	20	Saint Vincent and Grenadines	105						
21	Norway	5206	21	Maldives	88						
22	Denmark	5091	22	Grenada	83						
23	Hong Kong SAR	4643	23	Dominica	37						
24	Ireland	4625	24	Montserrat	10						
25	Estonia	4323									
26	Israel	4299									
27	Puerto Rico	3207									
28	Singapore	3076									
29	Slovenia	2051									
30	Kuwait	1195									
31	Malta	646									
32	Cyprus	620									
33	Luxembourg	315									
34	Oman	314									
35	Brunei Darussalam	137									
36	Qatar	129									
37	Aruba	49									
38	Saint Kitts and Nevis	25									
39	Anguilla	4									

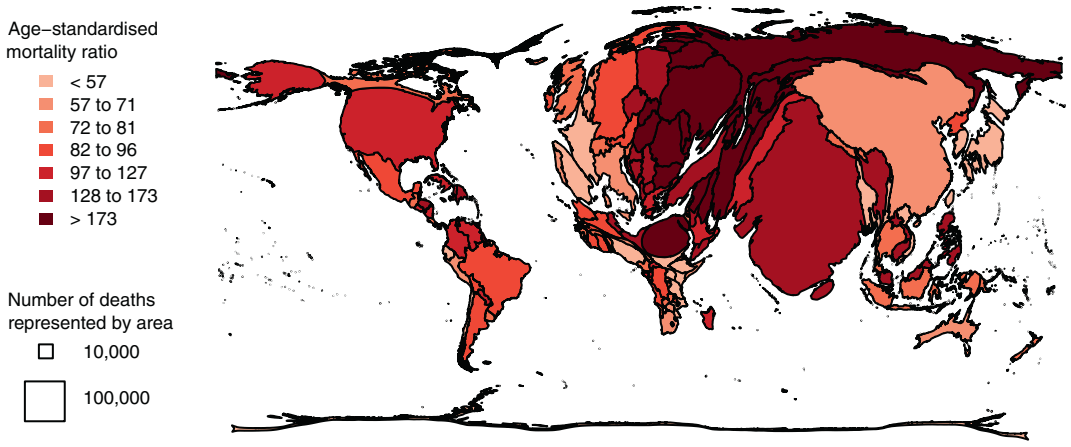

Fig. 1. Cartogram showing the worldwide distribution of IHD mortality using 2010 estimates from the Institute for Health Metrics and Evaluation.

because their mortality rates are some of the highest and lowest in the world and recent data was available. In men there was a 2.3- to 2.9-fold increase in IHD mortality per decade and a 3.2- to 4.5-fold increase in women.

3.3. Time trends in age-standardised IHD mortality rates

Fig. 3a and b shows the trends in crude death rates and age standardised mortality respectively in 20 countries between 2001 and 2012 for which extensive longitudinal data were available, predominantly European countries.

In these countries, crude death rates have remained stable in recent years (Fig. 3a). In contrast, there has been a general decline in directly standardised mortality rates in these countries between 2001 and 2012 (Fig. 3b). These data include both high income countries as well as countries in Eastern Europe where, despite high standardised mortality rates, an improvement in reducing these rates is noticeable in recent years.

3.4. Availability of data

At least one year of IHD mortality data was available for 137 countries between 2001 and 2012. Table 2 shows the lag in provision of mortality data to the WHO. Data were not available for any country for 2013. The WHO states that this is because "Countries usually submit data to WHO within 12–18 months after the closure of their records for the calendar year. Data checking, compilation and verification takes considerable time at the country level [12]." IHD mortality data for 2012 were only available in 13 countries. Over half of the world's countries (113/216) have provided IHD mortality data for 2008 or later.

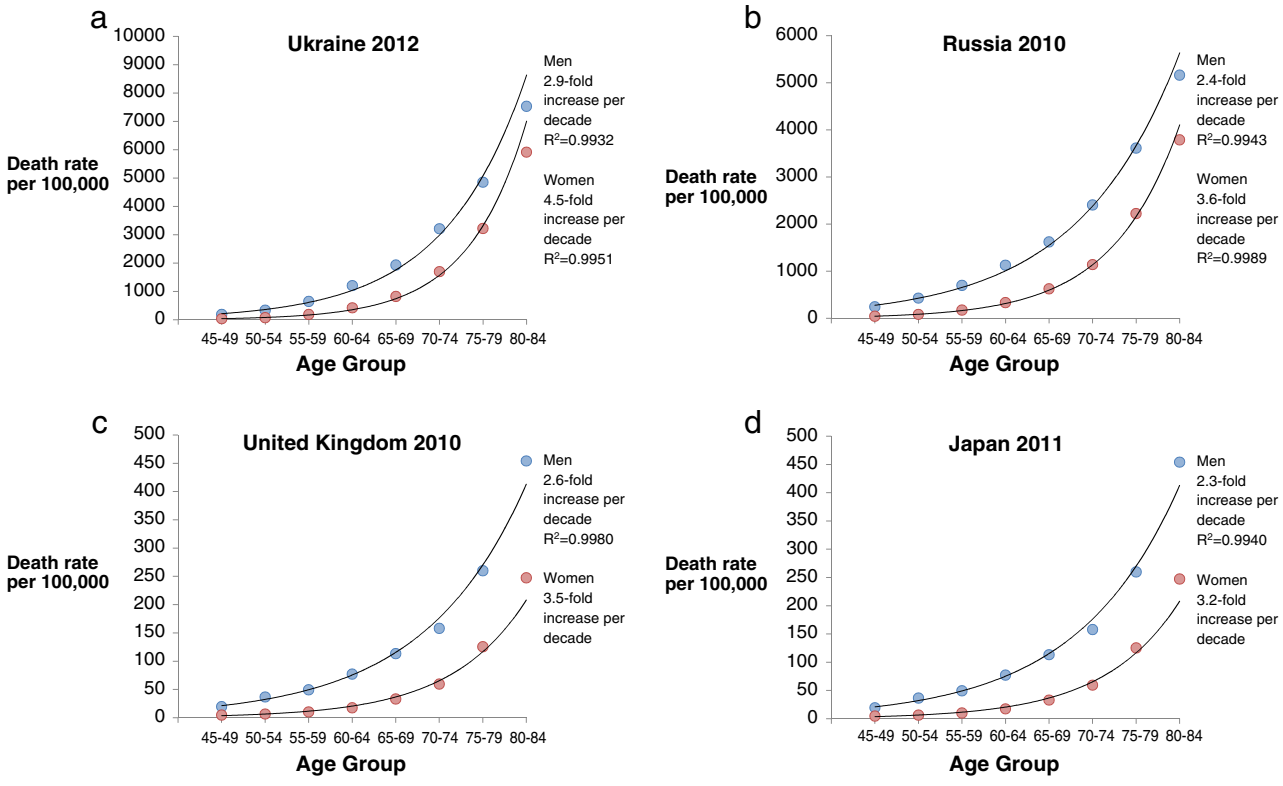

Fig. 2. Variation in mortality with age for (a) Ukraine, (b) Russia, (c) the United Kingdom and (d) Japan.

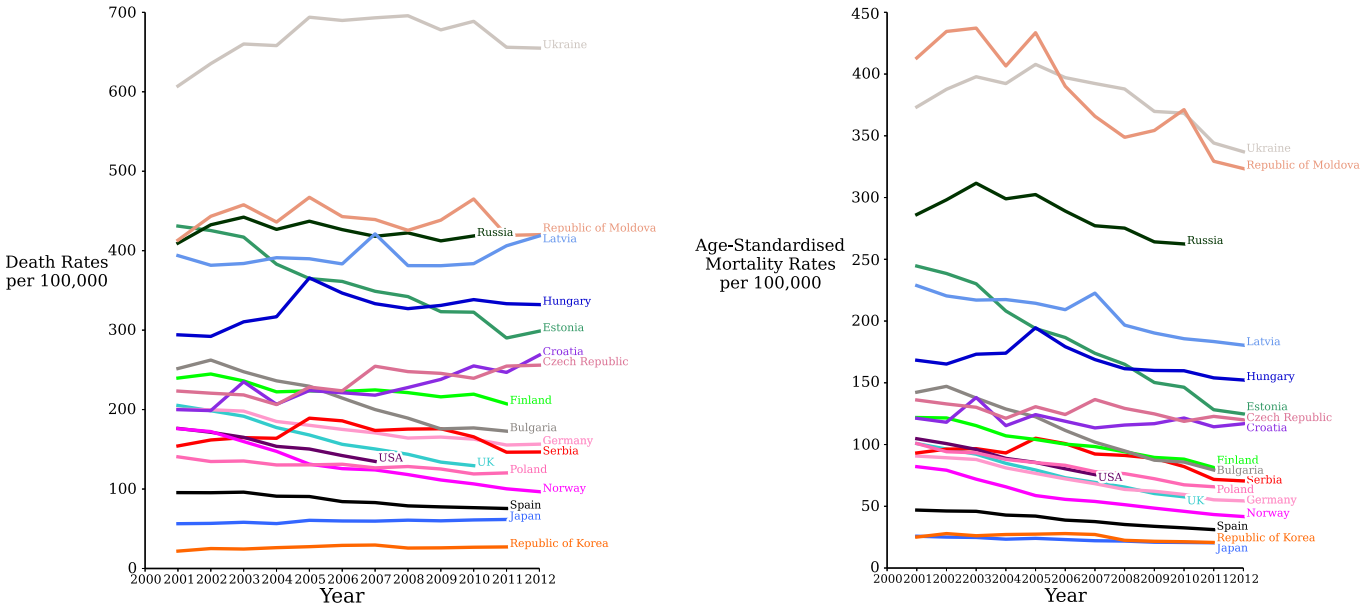

Fig. 3. Changes in (a) crude death rates and (b) directly standardised mortality rates from IHD for selected countries between 2001 and 2012.

4. Discussion

IHD remains the leading cause of death worldwide. IHD mortality data show that the largest numbers of IHD deaths occurred in Russia, the United States of America and Ukraine (Table 1). However, estimates indicate that India and China, countries for which no recent mortality data is available, have even larger numbers of deaths (Fig. 1).

The marked age dependence of IHD mortality rate is concordant between countries even when the countries have very different mortality rates. Provision of IHD mortality data from most countries is limited for reasons which are not clear.

4.1. Visual display of numbers of deaths and standardised mortality ratios

Displaying a modified map with country areas representing the numbers of deaths is a convenient way to convey to the reader the global geographical distribution of IHD mortality events. Simultaneously the colour of each country can be used to represent the standardised mortality rate in that country. This allows the reader to both assess the relative cardiovascular risk of different countries and the magnitude of its contribution to the global burden of IHD deaths.

The cartogram shows that India and China contribute a large proportion of the planet's IHD deaths out of proportion to their true land area. Part of this is because of higher population density in these countries. In the case of India there is a contribution of higher standardised mortality rate as can be seen from its colour being darker than, for example, Western European countries. However, the standardised mortality rate in China is comparable to that of Western Europe as can be seen from their colours.

The cartogram shows that many countries of the Former Soviet Union and Central Asia have a high standardised mortality rate as evidenced by the dark colouring.

4.2. Data availability

Data take time to emerge. As of February 2014, only 13 countries have provided IHD mortality data for 2012. Only just over half the countries have provided any data after 2007. Of the remainder a small group of 24 countries have provided data in some previous years. The remaining 79 have never provided IHD mortality data in the ICD9 or ICD10 formats to the WHO. These countries include India and China which are estimated to be experiencing large numbers of IHD deaths making a major contribution to the global burden of IHD mortality. Whilst resources may be limited in some countries like India, they may be less so in countries like China and should not be so in the United Arab Emirates whose GNI per capita is in excess of US $40,000.

Where data are missing, methods can be used to estimate mortality but there is a risk of introducing error. Provision of this information to the WHO would assist with evaluation of the global burden of disease and in national and international health resource planning. The task is not insuperable, as evidenced by delivery of data from countries such as Serbia and the Republic of Moldova with creditable timeliness.

5. Conclusions

In many countries which have provided substantial longitudinal data there has been a continuing trend of reduction in age-specific death rates. Total IHD death rates have remained relatively stable due to an aging population.

Data do not become available for international comparison quickly, with 103 of the world's 216 countries not having provided any data after 2007. Greater focus on providing reliable data would greatly assist international efforts on strategic healthcare planning.

Visual display of IHD mortality on a cartogram can assist recognition of the separate but related issues of age-standardised mortality and total IHD mortality burden in individual countries. The countries making the greatest contribution to global IHD burden are India and China. However, there are many countries with much higher age-standardised mortality rates which may in the future contribute progressively greater numbers to global IHD deaths.

Acknowledgements

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Table 2
Year of latest available data for each country.

2012			
Armenia	Bulgaria	Croatia	Czech Republic
Estonia	Germany	Hungary	Latvia
Norway	Moldova	Serbia	Seychelles
Ukraine			
2011			
Australia	Austria	Bosnia and Herzegovina	Brunei Darussalam
Costa Rica	Cyprus	Denmark	Egypt
Fiji	Finland	Greece	Hong Kong SAR
Israel	Japan	Kuwait	Luxembourg
Maldives	Malta	Mauritius	Morocco
Netherlands	Nicaragua	Poland	Portugal
Qatar	Republic of Korea	Romania	Singapore
Spain			
2010			
Anguilla	Argentina	Aruba	Belgium
Brazil	Cuba	Dominica	Dominican Republic
Ecuador	France	Georgia	Grenada
Ireland	Italy	Kazakhstan	Kyrgyzstan
Lithuania	Mexico	Montserrat	Oman
Paraguay	Peru	Puerto Rico	Rodrigues
Russia	Saint Kitts and Nevis	Saint Vincent and Grenadines	Slovakia
Slovenia	Sweden	Switzerland	TFYR Macedonia
United Kingdom	United States of America		
2009			
Antigua and Barbuda	Bahrain	Belarus	Belize
British Virgin Islands	Canada	Cayman Islands	Chile
Colombia	El Salvador	French Guiana	Guadeloupe
Guatemala	Guyana	Iceland	Jordan
Martinique	Montenegro	New Zealand	Occupied Palestinian Territory
Panama	Rèunion	Saint Pierre and Miquelon	Saudi Arabia
South Africa	Suriname	Turks and Caicos Islands	Uruguay
Venezuela			
2008			
Bahamas	Barbados	Bermuda	Iraq
Malaysia	Philippines	Saint Lucia	Trinidad and Tobago
2007 or earlier			
Albania	Azerbaijan	Bolivia	Falkland Islands (Malvinas)
Haiti	Honduras	Jamaica	Kiribati
Macau	Monaco	Mongolia	Netherlands Antilles
Pakistan	Papua New Guinea	San Marino	Sao Tome and Principe
Sri Lanka	Syrian Arab Republic	Tajikistan	Thailand
Turkmenistan	Uzbekistan	Virgin Islands (USA)	Zimbabwe
No IHD data in ICD9 or ICD10			
Afghanistan	Algeria	Andorra	Angola
Bangladesh	Benin	Bhutan	Botswana
Burkina Faso	Burundi	Cote d'Ivoire	Cambodia
Cameroon	Cape Verde	Central African Republic	Chad
China	China: Province of Taiwan only	Comoros	Congo
Cook Islands	Democratic People's Republic of Korea	Democratic Republic of the Congo	Djibouti
Equatorial Guinea	Eritrea	Ethiopia	Gabon
Gambia	Ghana	Guinea	Guinea-Bissau
India	Indonesia	Iran (Islamic Republic of)	Kenya
Lao People's Democratic Republic	Lebanon	Lesotho	Liberia
Libyan Arab Jamahiriya	Madagascar	Malawi	Mali
Marshall Islands	Mauritania	Mayotte	Micronesia (Federated States of)
Mozambique	Myanmar	Namibia	Nauru
Nepal	Niger	Nigeria	Niue
Palau	Rwanda	Ryu Kyu Islands	Samoa
Senegal	Sierra Leone	Solomon Islands	Somalia
South Sudan	Sudan	Swaziland	Togo
Tonga	Tunisia	Turkey	Tuvalu
Uganda	United Arab Emirates	United Republic of Tanzania	Vanuatu
Viet Nam	Yemen	Zambia	

References

[1] WHO | The top 10 causes of death. [Internet] WHO; 2013 (accessed on 30 Mar 2014 available from: http://www.who.int/mediacentre/factsheets/fs310/en/).

[2] Finegold JA, Asaria P, Francis DP. Mortality from ischaemic heart disease by country, region, and age: statistics from World Health Organisation and United Nations. Int J Cardiol Sep 30 2013;168(2):934–45.

[3] Area cartograms: their use and creation. [Internet] Danny Dorling; 1996 (accessed on 30 Mar 2014 available from: http://www.dannydorling.org/?page_id=1448).

[4] WHO | Information on estimation methods. [Internet] WHO; 2011 (accessed on 30 Mar 2014 available from: http://www.who.int/gho/ncd/methods/en/).

[5] Methods for estimating adult mortality. [Internet] United Nations; 2002 (accessed on 30 Mar 2014 available from: http://www.un.org/esa/population/techcoop/DemEst/methods_adultmort/methods_adultmort.html).

[6] Murray CJL, Rajaratnam JK, Marcus J, Laakso T, Lopez AD. What can we conclude from death registration? Improved methods for evaluating completeness. PLoS Med Apr 2010;7(4):e1000262.

[7] WHO | Download the raw data files of the WHO Mortality Database. [Internet] WHO; 2014 (accessed on 30 Mar 2014 available from: http://www.who.int/healthinfo/statistics/mortality_rawdata/en/).

[8] Per capita GNI at current prices — US dollars. [Internet] United Nations Statistics Division; 2013 (accessed on 30 Mar 2014 available from: http://data.un.org/Data.aspx?d=SNAAMA&f=grID:103;currID:USD;pcFlag:1).

[9] Changes in country classifications | data. [Internet]. [Accessed on 30 Mar 2014]. Available from: http://data.worldbank.org/news/2010-GNI-income-classifications.

[10] Ahmad OB, Boschi-Pinto C, Lopez AD, Murray CJ, Lozano R, Inoue M. Age standardization of rates: a new WHO standard. [Accessed on 30 Mar 2014]; available from: http://wwwlive.who.int/entity/healthinfo/paper31.pdf; 2001.

[11] Global Burden of Disease Study 2010. [Internet] Institute for Health Metrics and Evaluation; 2013 (accessed on 30 Mar 2014 available from: https://cloud.ihme.washington.edu/public.php?service=files&t=d559026958b38c3f4d12029b36d783da&path=//2010).

[12] WHO Mortality Database documentation 25 February 2014 update. [Internet] World Health Organisation; 2014 (accessed on 30 Mar 2014 available from: http://www.who.int/healthinfo/statistics/mortality_rawdata/en/).